tral, as they are in the Lamellibranchiata, and, without any great disturbance of the parts, all the viscera will assume their proper positions.

Before the probability of this determination of the homological relations can be admitted, it is necessary to ascertain the true nature of the ganglion, which, as we have seen, is placed between the respiratory tubes. In the Polyzoa the ganglion is placed on the rectal aspect of the œsophagus, immediately below the mouth, and gives its nerves to the tentacles and to the œsophagus in the direction of the mouth, but none to the "endocyst" (mantle) or to any other organ. Therefore it can scarcely be homologous with the ganglion in the Tunicata, which distributes all its nerves to the walls of the respiratory tubes (which are mere prolongations of the mantle) and to the mantle itself. In the Lamellibranchs, however, there is a ganglion (or a pair of ganglions), namely the branchial, the most constant in these animals, situated upon the posterior adductor muscle, which, besides supplying the gills, gives nerves to the dorsal portions of the mantle and to the respiratory tubes, parts which are the undoubted homologues of those which receive the nerves from the ganglion in the Tunicata. It therefore seems impossible to avoid the conclusion that the ganglion in the latter is the true representative of the branchial ganglion in the Lamellibranchiata: ganglia supplying homologous parts must likewise be homologous.

This determination of the nature of the ganglion agrees well with its position, which in relation to the respiratory tubes is almost precisely similar to that of the branchial ganglion. And we thus find in the nervous element a corroboration of the above suggestion as to the homological relation of the branchial sac.

Notes on some Insect- and other Migrations observed in Equatorial America. By Richard Spruce, Esq. Communicated by the President.

[Read June 6, 1867.]

In endeavouring to trace the distribution of plants in the Amazon valley, and to connect it with that of animals, I have been struck with the fact that there are certain grand features of the vegetation, which prevail throughout Cisandine America, within the tropics, and even beyond the southern tropic,—features independent of the actual distribution of the running waters, partly also of the

geological constitution, and even of the climate—to which the range of the larger Mammals and Birds corresponds in a considerable degree, but not that of any one class or tribe of animals, and especially not of lepidopterous Insects. These features depend on the prevalence of certain groups, or even of single species, of plants over vast areas:—one set prevailing in the Virgin or Great Forests (*Caa-guaçú* of the Brazilians, *Monte Alto* of the Venezuelans) which clothe the fertile lands beyond the reach of inundations, and constitute the great mass of the vegetation; another in the Low or White Forests (*Caa-tinga*, *Monte Bajo*)—those curious remnants of a still more ancient and humbler but surpassingly interesting vegetation, which (especially on the Rio Negro and Casiquiari) are being gradually hemmed in and supplanted by the sturdier growth of the Great Forests, wherein they are interspersed like flower-beds in a shrubbery; another in the Riparial Forests (*Ygapú* or *Gapó*, *Rebalsa*), on lowlands bordering the rivers, and laid under water for several months in the year, where the trees when young, and the bushes throughout their existence, must have the curious property of being able to survive complete and prolonged submersion, constituting for them a species of hybernation; a fourth in the Recent Forests (*Caa-puéra*, *Rastrojo*), which spring up to replace the Primitive Forests destroyed by man, and, notwithstanding their weedy character, consist chiefly of shrubs and trees; a fifth in the Savannas or Campos—grassy or scrubby knolls, or glades, or hollows (dried-up lakes), which bear a very small proportion indeed to the vast extent of woodland, in the Amazon valley proper, but towards its northern and southern borders compete with the woods for the possession of the ground, and in the centre of Venezuela enlarge to interminable grassy "llanos" or plains.

From an elevated site that should embrace the landscape on all sides to the extreme limit of vision, as, for instance, from the heights at the confluence of the Rio Negro and Amazon, or, better still, from one of the steep granite rocks that overlook the noble forests of the Casiquiari, a practised eye would distinguish the various kinds of forest by their aspect alone. The Virgin Forests are distinct enough by the sombre foliage of the densely-packed, lofty trees, out of which stand, like the cupolas, spires, and turrets of a large city, the dome-shaped or pyramidal or flat-topped crowns of still loftier trees, overtopping even the tallest palms, both palms and trees being more or less interwoven with stout gaily-flowering lianas; the White Forests by the low neat-growing and

thinly-set trees and bushes, with scarcely any lianas—the palms few, but peculiar, and often odd-looking,—on a near view by the greater abundance of Ferns, especially on the trees, and sometimes of terrestrial Aroids and Cyclanths; the Recent Forests by their low irregular tangled growth, paler foliage, and general weedy aspect; the Riparial Forests, even where the water is not visible, by the varied tints of the foliage, and by the trees rarely equalling those of the Virgin Forest in height—sometimes, indeed, beginning on the water's edge as low bushes, thence gradually growing higher as they advance inland, until at the limit of inundations they mingle with the primeval woods, and are almost equally lofty,—by the greater proportion of herbaceous lianas which drape the trees and often form a curtain-like frontage,—and by the abundance of Palms, whereof the taller kinds usually surpass the exogenous trees in height, and (the Fan-Palms especially) often stretch in long avenue-like lines along, or parallel to, the shore. On some black-water rivers, such as the Pacimoni, the Atabapo, and the Rio Negro in some parts of its course, the breadth of inundated land is entirely clad with bushes and arbuscules of very equable height, on the skirts of which the Virgin Forest rises abruptly to a height more than twice as great. This is called by the natives "Caatinga-gapó."

Besides these differences of aspect, the natives will tell you there are other more intrinsic ones,—for instance, that the riparial trees have softer and more perishable timber, as well as inferior fruits; while the Caatingas, with a far greater show of blossom, have hardly any edible fruit at all, and very few indeed of the trees rise to the magnitude of timber-trees. And yet, when the constituent plants of the different classes of forest come to be compared together, they are found to correspond to a degree quite unexpected; for, although the species are almost entirely diverse, the differences are rarely more than specific. It is only in the Caatingas that a few genera, each including several species, seem to have taken up their exclusive abode: such are *Commianthus* among Rubiaceæ, *Pagamea* among Loganiaceæ, *Myrmidone* and *Majeta* among Melastomaceæ; and there are a few other peculiar genera, chiefly monotypic. But, of the riparial plants, nearly every species has its congener on *terra firma*, to which it stands so near, that, although the two must of right bear different names, the differences of structure are precisely such as might have been brought about by long exposure even to the existing state of things, without supposing them to date from widely different con-

ditions in the remote past; and this is especially true of such genera as *Inga*, *Pithecolobium*, *Lecythis*, and of many Myrtles and Melastomes, Sapotads, &c.

As an illustration of the features which tend to impress a certain character of uniformity on the vegetation of the Amazon region, I will take the case of a single tree, *Bertholletia excelsa* (H. & B.)—perhaps the noblest tree of the Amazon region, and the most characteristic of its Virgin Forests—and briefly sketch its distribution. In aspect and foliage it is not unlike a gigantic Chestnut-tree; and the seeds (the Pará nuts of commerce), if not much like chestnuts in their trigonous bony shell, are not very different in taste, whence the Brazilian name of the tree (*Castanheira*), and of the seeds (*castanhas*). This tree is found almost throughout the Amazon valley, both to north and south, chiefly wherever there is a great depth of that red loam which it pleases M. Agassiz to call "glacial drift." About Pará itself there is no lack of it, especially in the fine woods of Tauaú; and 1200 miles further to the west it may be seen in some abundance on the very banks of the Amazon, between Coary and Ega, at a part called Mutúncoára (Curassow's Nest), where steep red earth-cliffs border the river and forest; while it extends many hundred miles up the Purús and other southern affluents. North of the main river I have seen it at many points—for instance, in the forests of the Trombetas and at the falls of the Aripecurú, in various places along the Rio Negro, where one village (Castanheiro) takes its name from it, and on the Casiquiari and Upper Orinoco, where it was first seen and described by Humboldt and Bonpland.

A magnificent palm, *Maximiliana regia* (Mart.)—Inajá of the Amazon, Cocurito of the Orinoco—frequently accompanies the *Bertholletia*, and is still more widely and generally dispersed. I have seen it as far to the south as in 7° lat.; and in $5\frac{1}{2}$° N. lat., at the cataracts of the Orinoco, it is still as abundant as on the Amazon. It even climbs high on the granite hills. On one which I ascended near the falls of the Rio Negro, an Inajá palm occupied the very apex, at 1500 feet above the river; and with the telescope I have distinctly recognized this palm at a much greater elevation on Duida and other mountains. Both the tree and the palm range to northward and southward beyond the limits of my own explorations; and there are a few other arborescent plants which stretch all through South America, from the base of the coast-range of Caracas (or even in a few cases from the West-India Islands) to the region of the river Plate; but these are chiefly

trees such as sprinkle the savannas, or are gathered into groves, along both the northern and southern borders of the great Amazonian forest-belt, wherein they now barely exist on the bits of "campos" that at wide intervals break the monotony of the woodland—although they probably at some antecedent period ranged continuously from north to south.

In other cases, closely allied species occupy distinct areas. One of the finest fruits of Equatorial America, the Cocura (*Pourouma* of Aublet), is borne in large grape-like bunches on trees of the Breadfruit tribe, having large palmatifid hoary leaves, quite like those of their near allies the Cecropias. Now the Cocura of the mid-region of the Rio Negro, of the Japurá, and of the Upper Amazon or Solimões, is *one* species (*Pourouma cecropiæfolia*, Mart.), while that of the mouth of the Rio Negro and adjacent parts of the Amazon is a very distinct and smaller-fruited species (*P. retusa*, Spruce), and that of the Uaupés is a third species (*P. apiculata*, Spruce), all three being so plainly diverse that the Indians distinguish them by adjective names, although that diversity or divergence, as in a vast many parallel instances, is but a measure of the time that has elapsed since their derivation from a single stirp.

But the most general cause of resemblance lies in this fact, that there are many orders and families of plants whereof many of the species are confined to limited areas, and yet, throughout the Amazon valley, each order, or family, will be everywhere represented by about the same number of individuals and species, having to each other nearly the same correlation, as regards aspect and sensible properties—provided always that the conditions of growth (as above defined) be the same; so that a plant which serves as food for any particular animal or tribe of animals in a given locality, is pretty certain to have its congener (or at least its coordinate) in any other locality of the same region.

The Riparial Plants of the Amazon (such, namely, as grow between ebb- and flood-mark, or within the limits to which the annual inundations extend) range in many instances from the very mouth of the river up to the roots of the Andes; and I do not yet know of a single tree which is not found both on the northern or Guayana shore and on the southern or Brazilian*. The most notable example of this extensive range is the Pao Mulatto, or Mulatto Tree (*Enkylista*, Benth.), a tall elegant tree allied to the Chinchonas, and conspicuous from its deciduous brown bark,

* Hence I suspect that those insects of the south side of the Amazon which have been identified with Guayana species, belong chiefly to the Riparial forests.

which grows everywhere on lands flooded by the Amazon, and, from its accessibility and the readiness with which its wood burns while green, supplies a great part of the fuel consumed by the steamers that navigate the Amazon. It is almost equally common on some of the white-water tributaries; I have seen it, for instance, far away up the Huallaga to the south, and up the Pastasa to the north. Two of the commonest river-side Ingas of the Amazon (*I. splendens*, W., and *I. corymbifera*, Benth.) reappear together on the Upper Casiquiari and Orinoco; and similar instances might be multiplied indefinitely.

Streams of black or clear water have also their proper riparial vegetation, some species being apparently repeated on all of them. For example, many of the trees of the inundated margins of the Tapajoz (some of them undescribed when I first gathered them) I found afterwards on the Rio Negro up to its very sources—although none of them inhabit the shores of the Amazon, either between the mouths of those two affluents or elsewhere. A few recur on the Teffé and other black-water streams entering still further to the west, and even on similar affluents of the Orinoco.

Here, at least, would seem to be a case of the vegetation depending on the distribution of the running waters; but in reality both the kind of water and the vegetation nourished by it depend entirely on the nature of the soil, those rivers which run chiefly through soft alluvial bottoms being turbid, while those that have a hard rocky bed run clear; and the two classes of rivers are repeated over and over throughout the length and breadth of the Amazon region. Into the black Rio Negro runs that whitest of rivers, the Rio Branco, and imparts to the vegetation of the former, for a little way below their confluence, quite an Amazonian character*. The two largest tributaries of the Casiquiari, namely the Pacimoni and the Siapa, run nearly parallel through a longish course, and at rarely more than fifteen miles apart; yet the former has clear dark water, and the latter is excessively muddy. Moreover, when I explored the Pacimoni to its very sources, I found it divide at last into two nearly equal rivulets, whereof the one had white and the other black water. The true riparial vegetation in all these, and in hundreds of other cases, is invariably modified after the same fashion by the colour of the waters. How it became what it is, and how it came there at all, are questions not to be discussed here.

* Here, for instance, is the only locality throughout the Rio Negro for *Bombax Munguba*, a fine silk-cotton tree abounding on the Amazon.

After what has been said, it is scarcely necessary to add that many species of plants which grow down to the very coast in Guayana exist also in the Peruvian province of Maynas—that is, at the eastern foot of the Andes, and even up to a height of a few thousand feet in those mountains,—*e. g.* Humboldt's Willow (*Salix humboldtiana*, W.) and the Cannon-ball Tree (*Couroupita guianensis*, Aubl.), called *Aia-uma*, or Dead Man's Head, in Maynas; while the proportion of Orinoco plants repeated on the Amazon is much greater than that of the plants of South Brazil. Nor does this uniformity of character, and the constant recurrence of certain species, preclude the possibility of the flora being wonderfully rich; for I have calculated that by moving away a degree of either latitude or longitude, I found about half the species different; while in the numerous "caatingas" I have explored I always found a few species in each that I never saw again, even in other "caatingas".

The importance of inquiries of this class is obvious, even from a zoological point of view; for that an animal should flourish in any region it must there find suitable food; and there is perhaps no part of the world where so large a proportion of the animals is so directly vegetarian in its diet. I have reason to believe that there is no carnivorous animal on the Amazon and Orinoco which does not occasionally resort to vegetables, and especially to fruits, for food,—not always of necessity, but often from choice. When, however, we come to consider and compare the distribution of the various classes and subordinate groups of animals, we see that the range of a fruit-eating species or tribe can rarely correspond to that of one which feeds on leaves—and similarly of other pairs of differences or contrasts in the nature of the food,—that, in short, the only animals which can be expected to range from sea to sea in a wide continent are a few general feeders and their parasites, the larger beasts of prey, and the scavengers, such as Vultures among birds (and perhaps Termites among insects).

As to the distribution of the Lepidoptera in the Amazon valley, it is plain that it can rarely correspond to the grander features of the vegetation, for the simple reason that the food of caterpillars is scarcely ever the foliage &c. of the loftier forest-trees, but chiefly of soft-leaved undershrubs and low trees (1) which grow under the shade of the forest and have, many of them, a restricted range, or (2) which spring up where the primeval woods have been destroyed, and in waste places near the habitations of men, and whose range in many cases is coextensive at least with Cisandine Tropical

America. The bushy trees and the luxuriant herbs which border savannas and "caatingas" and broad forest-paths, and sometimes those which grow on the very edge of streams, are also apt to be infested by caterpillars. Of about two thousand forest-trees I have had cut down in the Amazon region for the sake of their flowers and fruits, very few indeed have been infested by caterpillars. A tall Leguminose (tree or liana) or Bombaceous species would sometimes have caterpillars on it; more rarely a Laurel or a Nutmeg; but a Fig or a Guttifer never. A vast number of trees and lianas of all sizes are, indeed, excluded from serving as food to caterpillars by their strongly resinous or else acrid and poisonous juices,—and many more on account of their hard leathery leaves, which are untouched except, rarely, by minute caterpillars that eat hemselves galleries in the parenchyma.

Of plants which afford food for caterpillars, Leguminosæ hold decidedly the first place; next to these rank Mallow-like plants (including Malvaceæ proper, Sterculiaceæ, Büttneriaceæ, and Tiliaceæ); then Melastomaceæ and Solanaceæ. Caterpillars armed with stinging hairs seem peculiarly partial to Leguminosæ, as I know to my cost, the bushy Inga trees in some parts being scarcely approachable when with flowers and young leaves. In the neighbourhood of Guayaquil, children that stray under the Tamarind-trees sometimes get severely stung by the hairy caterpillars that drop on them from the trees.

Other orders of plants on which I have encountered caterpillars are chiefly the following. Among Endogens: Grasses, Sedges, Palms, and Aroids—on all rather rarely; on Scitamineæ and Musaceæ more frequently. Among Exogens: Euphorbiaceæ (principally on those with aromatic foliage); Samydeæ; Bixaceæ; Vochysiaceæ; Sapindaceæ (few); Malpighiaceæ; Anonaceæ and Myristiceæ (rarely); Anacardiaceæ; Ochnaceæ (on very young leaves only, the adult foliage being hard and vitreous); Podostemeæ; Polygoneæ; Amarantaceæ; Piperaceæ; Lauraceæ (few); Chrysobalaneæ (often much infested); Combretaceæ; Myrtaceæ (rarely on true Myrtles, but a great pest to the large handsome flowers of the suborders Barringtonieæ and Lecythideæ); Passifloreæ; Cucurbitaceæ; Rubiaceæ (few out of the vast number of Amazon species); Compositæ (all weeds); Borragineæ; Verbenaceæ; Bignoniaceæ. Besides these, there are other orders, which contain a few species with mild juices, and leaves (and even wood) not too tough for a caterpillar's jaws, which are doubtless chosen by certain species of butterflies as food for their pro-

geny; and nearly all the very large flowers are apt to be plagued by caterpillars, as well as by the grubs of flies and beetles*.

Some caterpillars seem to have a decided taste for bitters; and narcotics are rarely objected to; indeed I should say that most insects are decidedly partial to them, while bees and wasps seem to have a positive pleasure in getting drunk. The very few phyllophagous beetles whose habits have come under my notice feed on narcotic plants. At the falls of the Rio Negro, just south of the equator, a common weed in the village of Saõ Gabriel is *Solanum jamaicense*, Sw., growing (when not disturbed) to the size of a currant-bush, and bearing large angular soft woolly leaves. In February 1852, there appeared swarms of a large black beetle, whose corpulent abdomen was barely half-covered by the elytra (whence I suppose it an ally of our Meloës), and whose sole food was this *Solanum*. Their feeding-times were the dusk of evening and morning, when they would arise, as it were, out of the earth, hover over the plants like a swarm of bees, and then settle down in such numbers that the plants were black with them. From one of the *Solanum*-plants I began to fill a bottle with beetles; but although I scared away twice as many as I captured, at the end of ten minutes nothing was left of the leaves but the midribs. A few beetles lingered on the *Solanum* all through the hot day, scarcely feeding at all, and apparently narcotized. I believe our own Oil-beetle eats the narcotic foliage of buttercups, but I know not if it ever goes the length of getting tipsy on it.

Before entering on the main object of this paper, which is to record the facts of certain migrations that have fallen under my notice—rather as problems to be solved by abler naturalists than myself, than with the pretension to offer any complete solution of my own—I may digress so far as to say that when I reached the Amazon in 1849, I considered myself fortunate in finding the zoological portion of the field already occupied by two such able naturalists as Messrs. Bates and Wallace, thus leaving me free to bestow my undivided attention on the botany. There are indisputable advantages in the concentration of one person's energies on a single kingdom of Nature; but in the consideration of many important general problems the disadvantages of this circumscribed range of observation are manifest. I could not, for instance, devote

* The above list has no further value than that of indicating, so far as my notes and recollections serve me, the kinds of plants which I have seeen most maltreated by caterpillars in the Amazon region.

any time or take any pains to ascertain the perfect insect of the larvæ which fed on my plants; nor can the zoologist keep a specimen of every plant which an animal feeds upon. When a zoologist, a botanist, and a geologist, each having had the requisite previous training, shall combine to explore anew the Amazon valley, they will be able to connect many facts which now unavoidably remain isolated, and to deduce therefrom many interesting particulars of the course and actual distribution of organized beings therein. For myself, I am free to confess that I too generally looked on the insect world as enemies to be avoided or destroyed. Mosquitos and ticks sucked my blood; cockroaches ate and defiled my provisions; caterpillars mutilated the plants when growing; and ants made their nests among the dried specimens and saturated them with formic acid, or even cut them up and carried them away bodily. I recollect my horror at coming home and finding my house invaded by an army of "Arriero" or "Sauba" ants, who had fallen on a pile of dried specimens, and were cutting them up most scientifically into circular disks whose radius was just equal to the artist's own longest diameter. The few notes on insects scattered through my journals relate, indeed, chiefly to ants—who deserve to be considered the actual owners of the Amazon valley, far more than either the red or the white man. In fine, when I venture to offer these imperfect jottings to the notice of zoologists, I feel that I can at best be considered only an interloper in a province not my own.

Having above indicated the kinds of plants apparently most in request with the larvæ of the Lepidoptera, I wish now to recall the attention of naturalists to certain transits or migrations of the adult insects across the Amazon, which have already been described by Messrs. Edwards, Wallace, and Bates, and perhaps by other travellers. The first time I fell in with such a migration was in November 1849, near the mouth of the Xingú, when I was travelling up the Amazon from Pará to Santarem; and it is thus sketched in my Journal:—

"The wind dropping in the afternoon, we accompanied a party of sailors from the brig, in a canoe, to what was now a muddy island, but in the rainy season had been a shoal some fathoms under water—we in quest of plants, and they of eggs of ducks and "tuyuyús"; but after stumping about for above an hour in the hot mud, which parboiled our legs and feet, we reembarked, having found no plants except a *Pontederia* and a *Cyperus*, and the

sailors no eggs at all. As we returned to the brig we saw a vast multitude of Butterflies flying across the Amazon, from the northern to the southern side, in a direction about from N.N.W. to S.S.E. They were evidently in the last stage of fatigue: some of them attained the shore; but a large proportion fell exhausted into the water, and we caught several in our hands as they passed over the canoe. They were all of common white and orange-yellow species, such as are bred in cultivated and waste grounds, and, having found no matrix whereon to deposit their eggs to the northward of the river (the leaves proper for their purpose having probably been already destroyed, or at least occupied, by caterpillars), were going in quest of it elsewhere."

The very little wind there was blew from between E. and N.E.; therefore *the butterflies steered their course at right angles to it*; and this was the case in subsequent flights I saw across the Amazon, although when the wind was strong the weaker-winged insects made considerable leeway, and would doubtless most of them succumb before reaching land. But the most notable circumstance is that *the movement is always southward*, like the human waves which from the earliest times seem to have surged one after the other over the whole length of America, generating after a time a reflux northwards, as in the case of the empire of the Incas. Is this tendency southwards the continuation of an impulse given in the remote past by the influx at the north-eastern and north-western corners of America of races of insects as well as of men to people the vast continent, or to dispute its possession with beings already existing there? For, allowing their due weight to such motives as hunger and desire, they seem insufficient to explain a movement invariably directed towards the same point of the compass; and if, as I suppose, butterflies steer their flight at right angles to the wind, because they thus make most headway, why do they not sometimes cross from south to north, which would be quite as advantageous with an easterly wind, unless they inherit some instinct which constantly impels them southward?

Since my return to England I have read Mr. Bates's graphic description of a flight of butterflies across the Amazon below Obidos, lasting for two days without intermission during daylight. These also all crossed in one direction, from north to south. Nearly all were species of *Callidryas*, the males of which genus are wont to resort to beaches, while the females hover on the borders of the forest and deposit their eggs on low-growing, shade-loiyng *Mimosæ*. He adds, "The migrating hordes, so far as I

could ascertain, are composed only of males"*. It is possible, therefore, that in the flights witnessed by myself the individuals were all males—in which case the flights should probably be looked upon, not as migrations, but dispersions, analogous to those of male ants and bees when their occupation is done, and they are doomed by the workers to banishment, which means death. In the case I am about to describe, however, the swarms certainly comprised both sexes, although I know not in what proportion; and their movements were more evidently dependent on the failure of their food.

In the year 1862 I spent some months at Chanduy, a small village on the desert coast of the Pacific northward of Guayaquil, where one or two smart showers are usually all the rain that falls in a year: but *that* was an exceptional year, such as there had not been for seventeen years before—with heavy rains all through the month of March, which brought out a vigorous herbaceous vegetation where almost unbroken sterility had previously prevailed. In April, swarms of butterflies and moths appeared, coming from the east, sucking the sweets of the newly opened flowers, and depositing their eggs on the leaves, especially of a *Boerhaavia* and of a curious Amaranth (*Frœlichia*, sp. n.) not unlike our common Ribgrass in external aspect—until caterpillars swarmed on every plant. New legions continued to pour in from the east, and, finding the field already occupied, launched boldly out over the Pacific Ocean, as Magalhaens had done before them, there to find a fate not unlike that of the adventurous navigator†. No better luck attended most of the offspring of their predecessors, especially those who fed on the *Boerhaavia*, which was much less abundant than the *Frœlichia*. The shoal of caterpillars advanced continually westward, eating up whatever to them was eatable, until, on nearing the sea-shore and the limit of vegetation, I used to see them writhing over the burning sand in convulsive haste to reach the food and shelter of some *Boerhaavia* which had haply escaped the jaws of preceding emigrants; but, failing this, thousands of them were scorched to death, or fell a prey to the smaller sea-side birds, to whom they were doubtless a rare dainty.

The explanation of this continual westward movement is not difficult. A few leagues inland, instead of the sandy coast-desert with here and there a tree, we find woods, not very dense or lofty, but where there is sufficient moisture to keep alive a few rem-

* 'Naturalist on the Amazons,' vol. i. p. 249

† Here also the course attempted to be steered by the insects was across the strong southerly breeze that was blowing.

nants of the above-mentioned herbs all the year round, and doubtless also of the insects that feed upon them. There are also cattle-farms; and around the wells from which water is drawn and served to the cattle, the same weeds are continually springing up; while the seeds, even of those that grew on the desert, remain imbedded in the sand and retain their vitality during all the years of drought. When the rains come on, therefore, they cause, as it were, a unilateral development of the vegetation from the forest across the open grounds, and a corresponding expansion of the insect-life which breeds and feeds upon it.

Results the same in principle, but diverse in mode, would take place under different local circumstances. Thus, if we suppose an oasis in the midst of a desert exposed to the same exceptional access of moisture as the desert of Chanduy with its forest skirt, there would be generated an extension of organic life radiating outwards in all directions.

Besides the migrations above recorded, I have many times in South America seen butterflies flying across rivers so wide that it is impossible to suppose they could be guided by any indication of sight or smell. Animals of higher organization and stronger reasoning-powers would probably turn aside along the shore of the river or ocean in quest of food for themselves and their offspring; but there are plainly cases where frail little creatures, such as butterflies, must go straight forward at a venture, and either attain their object or perish.

The movements of Ants registered in my journal are (as may be supposed) chiefly such as were hostile to myself, and they do not throw much additional light on their habits. "Ecitons," or Foraging Ants (called *Cazadoras* in Peru), seem to be true wandering hordes, without a settled habitation; for a certain number of them may always be seen carrying pupæ, apparently of their own species; but they sojourn sometimes for several days whenever they come upon suitable food and lodging. I have sometimes thought that the name "Tauoca" or "Taboca," applied to these ants on the Amazon, and also to bamboos of every kind, might indicate that they really made their nest in the cavities of bamboos; but I have been unable to verify it, although the name "Tachí" or "Tacýba" is certainly given to certain trees (*Tachia guianensis*, Aubl., *Triplaris surinamensis*, Camb., &c.) and also to a very wicked set of ants that inhabit the hollow branches of those trees. Hundreds of times I have come upon marching columns of "Ecitons" in the forest, and have sometimes paid dearly for my heedlessness in

stepping on them. Once at midnight, in the depth of the forest, I got entangled with an army of them on its march; which seems to show that they are on foot at all hours*.

The first time I saw a house invaded by *Cazadoras* was in November 1855, on the forest-slope of Mount Campana, in the eastern Peruvian Andes. I had taken up my abode in a solitary Indian hut, at a height of 3000 feet, for the sake of devoting a month to the exploration of that interesting mountain. The walls of the hut were merely a single row of strips of palm-trees, with spaces between them wide enough to admit larger animals than ants. One morning soon after sunrise the hut was suddenly filled with large blackish ants, which ran nimbly about and tried their teeth on everything. My *charqui* proved too tough for them; but they made short work of a bunch of ripe plantain, and rooted out cockroaches, spiders, and other suchlike denizens of a forest hut. So long as they were left unmolested, they avoided the human inhabitants; but when I attempted to brush them away they fell on me by hundreds, and bit and stung fiercely. I asked the Indian's wife if we had not better turn out awhile and leave them to their diversions. "Do they annoy you?" said she. "Why you see it is impossible for one to work with the ants running over everything," replied I. Whereupon she filled a calabash with cold water, and going to the corner of the hut where the ants still continued to stream in, she devoutly crossed herself, muttered some invocation or exorcism, and sprinkled the water gently over them. Then walking quietly round and round the hut, she continued her aspersion on the marauders, and thereby literally so damped their ardour that they began to beat a retreat, and in ten minutes not an ant was to be seen.

Some years afterwards I was residing in a farmhouse on the River Daule, near Guayaquil, when I witnessed a similar invasion. The house was large, of two stories, and built chiefly of bamboo-cane—the walls being merely an outer and an inner layer of cane, without plaster inside or out, so that they harboured vast numbers of cockroaches, scorpions, rats, mice, bats, and even snakes, although the latter abode chiefly in the roof. Notwithstanding the size of the house, every room was speedily filled with the ants. The good lady hastened to fasten up her fresh meat, fish, sugar, &c. in safes inaccessible even to the ants; and I was prompt to impart my experience of the efficacy of baptism by water in ridding a house of such pests. "Oh!" said she laughingly, "we

* See Mr. Bates's full and lucid account of these insects, *l. c.* p. 350.

know all that; but let them first have time to clear the house of vermin; for if even a rat or asnake be caught napping, they will soon pick his bones." They had been in the house but a very little while when we heard a great commotion inside the walls, chiefly of mice careering madly about and uttering terrified squeals; and the ants were allowed to remain thus, and hunt over the house at will, for three days and nights, when, having exhausted their legitimate game, they began to be troublesome in the kitchen and on the dinner-table. "Now," said Doña Juanita, "is the time for the water cure;" and she set her maids to sprinkle water over the visitors, who at once took the hint, gathered up their scattered squadrons, reformed in column, and resumed their march. Whenever their inquisitions became troublesome to myself during the three days, I took the liberty to scatter a few suggestive drops among them, and it always sufficed to make them turn aside; but any attempt at a forcible ejectment they were sure to resent with tooth and tail; and their bite and sting were rather formidable, for they were large and lusty ants. For weeks afterwards the squeaking of a mouse and the whirring of a cockroach were sounds unheard in that house*.

The most remarkable migration that I have myself witnessed in South America is that of the great Wood-Ibis (*Tantalus loculator*), called "Jabirú" in Brazil, "Gauán" in Venezuela, between the Amazon and the Orinoco, a distance of from 300 to 500 miles in a straight line, but a thousand or more following the course of the rivers. The migrations are so timed that the birds are always on the one river or the other when the water is lowest and there is most sandy beach exposed, affording the greatest extent of fishing-ground. In the years 1853 and 1854, when I was at San Carlos del Rio Negro (lat. 1° 53½′ S.) I saw them going northward in November and returning southward in May, and had the pleasure of having some of them stay to dine with me. One of their halting-places on their way to the Orinoco was on islands near the mouth of the Casiquiari, at only a few hours' journey above San Carlos. There I have seen them roosting on the tree-tops in such long close lines, that by moonlight the trees seemed clad with white flowers. They descend to sandy spits of islands to fish in the

* The ants called "Carniceras," or Butchers, in Maynas, are probably of a tribe distinct from the Foragers; for they are burrowing ants, and are said to prefer the flesh of human carcases to any other food. Padre Velasco, in his 'History of Quito,' assures us that they will make a perfect skeleton of a corpse the very day it is buried, and that they devour any disabled animal, however large, they find in the forest.

grey of the evening and morning, *i. e.* before betaking themselves to their eyry, and before resuming their journey on the following day. The scarcity of fish in rivers of clear or black water is well known; and even were they more abundant, this very clearness of the water would render it difficult for fish-eating fowls to catch them, unless when there was little light; hence, perhaps, the Ibis's choice of hours for fishing; and the turbid water poured into the Rio Negro by the Casiquiari dulls its transparency at that point, which makes it eligible for a fishing-station, leaving probably only a single day's stage for the travellers to reach the Orinoco. The Ibises, however, did not, as one might have supposed, turn up the Casiquiari, but held right on to the north, crossing the isthmus of Pimichin, and descending the Atabapo to the Orinoco. Some of them, I was told, would halt on the Guaviare, whose turbid waters, alligators, turtles, &c. quite assimilate it to the Solimões or Upper Amazon; and others push on to the Apuré; the former lot, however, are said to travel chiefly by way of the Japurá from the Amazon. Those that frequent the Upper Orinoco return in May; and their halting-place near San Carlos is not at the mouth of the Casiquiari, but on islands a day's journey below the village, so that they are at that season less persecuted by the Indians. If they went all the way down the Rio Negro in May, they would reach the Amazon long before its beaches began to be exposed; but it has been ascertained that they sojourn awhile on the Rio Branco, whose beaches are earlier uncovered. Flocks of Wild Ducks sometimes accompany the Ibises; and it is quite possible that some of the smaller aquatic and riparial fowls make similar migrations.

When the Ibises are roosting, a shot or two from a gun is enough to make the whole caravan take to flight and remove to some distance; but the Indians of San Carlos know better than to scare them away with fire-arms. They get into their canoes a little after midnight, creep silently up the river, and under cover of the night disembark beneath the trees where the Ibises are roosting. Then, when at break of day the birds wake up, and begin to stir and to be visible, the Indians pick them off with poisoned darts from their blowing-canes, in great numbers, before the bulk of the flock takes alarm; so that they mostly return to the village with great piles of dead Ibises; and although this lasts only three or four days, the quantity killed is so great that, what with fresh and what with barbacued game, everybody feasts royally for a fortnight; whereas throughout the rest of the year, the

dearth of provisions exceeds what I have experienced elsewhere in South America.

The Ibises doubtless undertake these voyages from the testimony and under the guidance of the elders, far more than from any inherited knowledge, or instinct; whereas the flights of butterflies one would think must be directed by instinct alone, without any aid from experience.

Many mammals wander far in search of food; and some that go in bands, such as wild Pigs and some Monkeys, have known feeding-places at certain times of the year, when some particular kind of fruit is in season there; so that the experienced Indian hunter often knows in what direction to bend his steps to fall in with a certain class of game. It is well known how fond all animals are of the Alligator-pear, which is the fruit of a large Laurel (*Persea gratissima*). I have seen cats prefer it to every other kind of food; and the wild cat-like animals are said to be all passionately fond of it. I have been told by an Indian that in the forests between the Uaupés and the Japurá, he once came on four Jaguars under a wild Alligator-pear-tree, gnawing the fallen fruits and snarling over them as so many cats might do. I have gathered flowers of at least four species of *Persea*, but was never fortunate enough to find one of them with ripe fruit; so that I have missed seeing the concourse of animals of many kinds which I am assured assemble in and under those trees, attracted by the fruit. While speaking of fruit-eating carnivora, it is worth mentioning that Dogs in South America often take naturally to eating fruit. I had in Peru a fine Spanish spaniel who, so long as he could get raw ripe plantains, asked for no better food. He would hold them between his paws, and pull off the skin in strips with his teeth so delicately as not to foul them in the least; so that I have occasionally eaten a plantain of his peeling.

I fancy Monkeys sometimes go on day after day along the banks of a river, their rate of progress depending on the quantity of food they find to eat and waste. I have watched them at this in a strip of Mauritia palms, which stretched for a distance of some days' journey along the banks of a river. The Chorro (Barrigudo of Brazil), a monkey of the hot plain, sometimes ascends the slopes of the Andes to five or six thousand feet, apparently to eat the fruit of the Tocte or Quitenian walnut (an undescribed species of *Juglans*), which is frequent at that elevation; but it is said never to pass a night there.

An Indian will tell you at what time of year certain fruit-eating

fowls are to be met with on the banks of a river, and at what time they must be sought for deep in the forest. I remember coming on a flock of one of the small Turkeys called Cuyubi (*Penelope cristata*, or an allied species), on the banks of the Uaupés, feeding on the fruit of so deadly a plant as a *Strychnos* (*S. rondeletioides*, Benth. in Pl. Spr.); but the succulent envelope of the fruit is innocuous, like that of our poisonous Yew. I had been forwarned that we might expect to find them at that particular spot, and thus occupied; so that we had our guns ready, and knocked several of them over. Indeed they were so tame, or so gluttonous, that when a shot was fired and one of them fell, the rest either took no heed or only hopped on to another branch and recommenced feeding; and it was not until we had fired and reloaded three or four times that the survivors took wing and flew off.

On the slopes of the volcano Tunguragua, the steepest and most symmetrical cone, though not the loftiest, of the Quitenian Andes, I have seen flocks of another Turkey (allied to, but distinct from, the Uru-mutún of Brazil) feeding on the plum-like drupes of the Motilon*, and on the berries of an undescribed Melastome. Besides these fruit-trees, there were also numerous fruit-bearing bushes near, including some true Brambles, Whortleberries, and a Hawthorn, all of which probably afforded food to the turkeys. This species seems to inhabit a zone, between 6000 and 10,000 feet, on the wooded flanks of Tunguragua, and within those limits to make the perpetual round of the mountain, being always found on that side where there is most ripe fruit to be had; and the birds are so tame and sluggish when feeding that the Indians easily kill them with sticks.

I should suppose that these and other gallinaceous birds have their fixed centres of resort (breeding- and roosting-places) from which they never stray far. Many Parrots and Macaws, I know, have. On the western slopes of the Quitenian Andes, immense flocks of Parrots ascend by day to a height of 8000 or 9000 feet, where they ravage the fields of maize and other grain, but always descend to certain warm wooded valleys, at 2000 to 4000 feet, to roost. The flights of vast multitudes of garrulous parrots and macaws to and fro between their roosting- and feeding-places, in the grey of the evening and morning, is one of the first things that strike the attention of the voyager on the Amazon.

The periodical appearance of certain birds in a district has been

* This name is given to *Symplocos cernua*, H. B. K., and also to two (or more) species of *Hieronyma*, all bearing edible drupes.

supposed by the inhabitants to have some mysterious connexion with the Christian festivals. Thus there are two beautiful little birds in Maynas, apparently belonging to different genera, for one of them is a Seven-coloured Tanager (*Pajaro de siete colores*), and the other (which I have not seen) is said to be of a bright blue colour and differently shaped; but both are called by the Indians *Huata-pisco* (Bird of the Year), because they make their appearance together, in large flocks, about the end of the year (people will tell you, precisely on Christmas-day), and remain throughout January, when they are seen no more until the same epoch comes round again. Mr. Bates has given a capital account of the movements of these hunting-parties of frugivorous and insectivorous birds, and of the superstition of the *Papa-uirá* or Patriarch Bird, who is supposed to head them (vol. ii. p. 333 *et seq.*). I suspect that this is something more than mere superstition, and that the Patriarch leaders are not one but several to each predatory band.

The abundance of fish in rivers of white water, and their scarcity in black-water rivers, may easily be shown to depend chiefly on the luxuriant littoral vegetation of the former and its scarcity or utter absence in the latter; for on the Rio Negro there are (with one notable exception*) no aquatics, and no shore grasses. Compare this with the broad fringe of tall succulent amphibious grasses on the shores of the Amazon, or detached and floating down it in the shape of large islands,—and of luxuriant aquatics, some fixed by roots, others floating (*Victoria*, *Jussiæa*, *Pontederia*, Frogbits, *Azolla*, *Salvinia*, *Pistia*, &c.), in deep still bays, but especially in lakes and channels communicating with the main river.

Some of the tributaries of the Rio Negro, however, have plenty of fish—namely, those of more or less turbid water, of which the Rio Branco holds the first rank, and after it come the Marauiá and Cauaborís, all entering on the left bank. In these rivers many Amazon fish are said to be repeated. About the mouth of the Rio Branco is the only place in the Rio Negro where the Pirarucú is found—that noble and remarkable fish, so characteristic of the Amazon. With the exception of the Pirarucú, most of the larger fish of the Amazon recur on the Upper Orinoco, above the cataracts; at least the Indians assert them to be the same, and to unskilled eyes they are undistinguishable. The Valenton, or Lablab, of the Orinoco (for instance) is surely the same as the large Pirahyba of the Amazon; the Pavon as the Tucunaré; the Ral-

* That of the Podostemons on granite rocks in the falls and rapids.

lado as the Surubím; the Murucútu as the Tambaquí; the Cajáru as the Pirá-arára, and so on. And if the Tambaquí of the Amazon have been correctly identified with *Cichla temensis*, then a large fish inhabiting the Temi, a small black-water tributary of the Orinoco, is the same one that abounds in the white water of the Amazon: but this needs confirmation; for white-water fish are known to shun black waters, and the Tambaquí is (so far as I know) absent from the Rio Negro proper, although it begins to be found a little way within the Casiquiari.

Supposing these fishes of the Amazon and Orinoco to be really identical, the question arises, Has there been and is there still any migration of fish between those rivers, by way of the Negro and the Casiquiari? or does their actual distribution date from the period when chains of lakes preceded the rivers to which the waters are now limited, and the colour and properties of the latter were more uniform throughout the whole region?

Many of the fishes of the Rio Negro travel up it to spawn, and especially up some of its tributaries; but the wanderings to and fro of fish in quest of food may be compared to that already noted of wild turkeys; for the principal subsistence of fish in the Rio Negro is on the fruits of riparial trees, some of which seem scarcely touched by either bird or monkey. A small laurel-like bush (*Caraipa laurifolia*, S.) lines the banks in many places, and bears damson-like drupes, which are the favourite food of that delicious fish the Uaracú or Aracú. When the ripe drupes are dropping into the water they attract shoals of Uaracú. Then the fisherman stations his canoe at dawn of day in the mouth of some still igarapé, overshaded by bushes of Uaracú-Tamacoarí (the native Indian name of the tree), and with his arrows picks off the fish as they rise to snatch the floating fruits. It ought to be mentioned that the fish of the Negro, if much fewer, are some of them perhaps superior in flavour to any Amazon fish, whereof the Uaracú is an example, and the large Pirahyba is another, the latter being so luscious that it is difficult to know when one has had enough of it, whereas the same or a very closely allied species of the Amazon is often scarcely edible*.

I have, in what precedes, purposely avoided speaking of the way in which animals prey on each other, because the ultimate measure of the amount of animal life must always depend on that of

* For further information on the fishes of the Rio Negro I must refer to Mr. Wallace's interesting account of that river ('Travels,' chs. 9, 10 & 16), and to Schomburgk's 'Fishes of Guiana.'

vegetable life, and not because I shut my eyes to the fact. In proof of this, take the following note from my Journal, under date May 15th, 1857, written on the Bobonasa, a tributary of the Pastasa, during my disastrous journey from Peru to Ecuador.

"This morning, coasting along a low shore, our men spied a small white Alligator sleeping in the sun, and killed him with their lances. His stomach was distended by some food he had taken, and on piercing it a snake's tail protruded. I laid hold of it and drew out the snake, which was tightly coiled up. It was still alive, though so much crushed below the head as to be unable to move away. It was a land species, not venomous, yellow, with black spots on the back, the body thick, passing abruptly into a short slender tail, the entire length just 3 feet, and its destroyer no more. Thus we go on preying on each other to the end of the chapter. This poor snake, while watching for frogs among the moist stones and roots, little dreamt he was about to serve for an alligator's meal, nor the alligator that he would soon be eaten up by Indians. The snake, however, died with an empty belly, while the alligator had gotten his breakfast, which was some consolation; for it is a very 'Let-us-eat-and-drink-for-tomorrow-we-die' sort of life that all God's creatures (man included) live in this wild region."

I leave these *disjecta membra* in the hands of naturalists, hoping that they may find among them some bone to pick. They bear on many problems for which there do not yet exist materials, nor do I possess the skill, requisite to arrive at a correct solution. On one point only I am pretty clear, viz. that almost every kind of animal now existing in Cisandine Tropical America might find suitable food and lodging on any parallel between the southern tropic and the mouth of the Orinoco; which is as much as to say that they would find everywhere, either the one plant they most delight to feed on, or others which might suit them almost or quite as well. The continual substitution of new forms encountered as we advance in any direction, does not, on a superficial view, show much correspondence between animals and plants—a fact which may be put otherwise, thus:—Suppose on a given area at the foot of the Andes every species of some class of animals to be distinct from those of the same class on an equal area at the mouth of the Amazon, it does not therefore follow that every plant is different on the two areas; we know, indeed, that such is not the case. Yet the modifications that have been and are still in progress among vegetable forms must have some correspondence with

those that take place in animals; for all the realms of Nature act and react on each other. The atmosphere and the earth (with its productions, animal and vegetable) are continually giving and taking; and as their actual relations to each other vary more widely at different points along the equatorial belt than elsewhere on the earth's surface, it is plain that what seems equilibrium is either oscillation or progress in some direction. If plants were the only organic existences, and there were no animals to aid in their reproduction, to feed upon them, to dispose of their dead carcasses, &c., the dominant forms would doubtless be quite different from what they are now. Darwin has shown by an admirable series of observations how necessary insect agency is to the fertilization of the flowers of many plants. Hence the organs of those insects and the parts of the flowers have been (and are being) continually modified, or moulded, the one on the other. I can conceive that if certain Orchids were henceforth entirely freed from the visits of insects, their flowers, notwithstanding the apparent permanence of inherited (though now useless) peculiarities, would immediately *tend* to revert to the symmetry which no doubt they possessed in the remote types. I have a good deal of evidence to show that in tropical countries many peculiarities of structure in the leaves and other parts of plants (prevailing through large suites of species and genera) have been brought about, and are still in part maintained, by the unremitting agency of insects, especially of Ants. These and many other matters require the fullest investigation before the precise relations of the changes, in animals and plants, that are taking place under our eyes can be properly understood and appreciated.

A Catalogue of Erycinidæ, a Family of Diurnal Lepidoptera.

By H. W. Bates, Esq., F.Z.S. &c., Assist. Sec. Roy. Geogr. Soc. (Communicated by George Busk, Esq., Sec. L.S.)

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The Family Erycinidæ has increased so greatly, both in genera and species, since the last time its members were passed in review (by Westwood, in Doubleday and Hewitson's 'Genera of Diurnal Lepidoptera,' in 1851), that a new catalogue of its contents is much required. It is my intention, in the present memoir, to endeavour to supply this want, and to suggest a plan of classification of the genera—a work which has not hitherto been at-